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Multi-beam X-ray ptychography using coded probes

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Ptychography is a high-resolution imaging technique known for being capable of reaching sub-10 nm resolution. A coherent beam is required to reach this resolution. Currently, the coherent fraction of the beam for third-generation synchrotron sources is only 10%. Thus, ptychography needs to isolate the coherent flux. Consequently, more than 90% of the incoming X-rays are wasted. This reduces the total flux on the sample, which leads to an increased scan time or reduced spatial resolution due to a lower signal-to-noise ratio. The need to choose between high resolution and a large field of view is often a show stopper for many experiments. This problem is especially dire for biological samples, where a single specimen often is not representative of a population. The latest advances in ptychographic algorithms provide the possibility of introducing mutually incoherent modes. This was adapted in recent developments for visible light microscopy with multiple independent beams. The sample is scanned simultaneously, not by one beam but by many, which can be mutually incoherent from each other. Each mode in the algorithm is used to reconstruct one beam and a corresponding region of the sample, expanding the scan area by the number of beams. We have successfully implemented this technique in the X-ray regime using up to 6 beams in parallel. Each beam was uniquely coded, which provided robust disentangling of the diffracted signal from different sample areas and thus artifact-free reconstructed object.

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